

17. Polymorphonuclear Leukocyte Response

Experiment MA-032

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ABSTRACT

Serial blood samples were obtained from the three crewmembers of the Apollo-Soyuz Test Project and from eight normal control subjects over an interval beginning 30 days before flight and ending 30 days after termination of the space flight. A laboratory was established onboard the recovery ship U.S.S. *New Orleans* (LPH-11) to perform tests on leukocytes from blood samples obtained immediately after recovery and on the following day. Inhalation of propellant gases by the crewmembers and the inception of corticosteroid therapy on the day following recovery provided an opportunity to investigate the possible effects of these factors on leukocyte function. The tests performed included total leukocyte count, differential count, measurement of leukocyte adhesion, evaluation of leukocyte migration and chemotaxis, assessment of phagocytic ability, and testing for cytoplasmic granules that stained for leukocyte acid and alkaline phosphatase. Together, these observations present a variety of *in vitro* studies that correlate with the function of polymorphonuclear leukocytes within the body.

INTRODUCTION

Various physiological, hematological, and serological measurements have been obtained

from crewmembers throughout the manned space flight program. Erythrocytes and lymphocytes have been intensively studied, but considerably less information has been obtained concerning the possible effects of space flight and weightlessness on polymorphonuclear leukocyte (PMN) function. Because these phagocytic cells are important in the defense of the body against infection and because an increasing number of clinical conditions have been recognized in which decreased PMN function is associated with increased susceptibility to infection, a variety of experiments were designed to test PMN function *in vitro* in relation to the events of the Apollo-Soyuz Test Project (ASTP). The goal of this experiment was to attempt to identify any measurable PMN alterations that might have a significant effect on planning future space missions of longer duration.

The experiment proceeded basically as planned, and all desired blood samples were obtained during the baseline, postflight, and later convalescent periods. The unplanned inhalation of propellant gases by the crewmembers during reentry and their subsequent hospitalization with the administration of adrenal corticosteroid therapy provided an opportunity to evaluate these factors in relation to leukocyte function (refs. 17-1 to 17-3).

The results of this experiment successfully documented that no consistent abnormality in PMN function (detectable by the *in vitro* methods used) occurred in the ASTP crewmembers as a result of the 9-day space flight. The experimental design was limited by the inability to test blood samples during the space flight. A broader experience, including studies performed on specimens obtained during weightlessness, will be required before final conclusions can be drawn.

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MATERIALS AND METHODS

The *in vitro* techniques used in the present experiment have been adapted from methods developed in this laboratory and in use among investigators of leukocyte function in other laboratories. The tests were first standardized using leukocytes obtained from a variety of normal control subjects. Control subjects for the experiment itself included the three members of the backup flightcrew and four volunteers from among the investigators conducting experiments onboard the U.S.S. *New Orleans*. Because it was not possible to obtain blood samples from the control subjects and from the crewmembers at exactly the same time, one control subject donated two separate blood samples (one with the other controls in the morning, and the other with the crewmembers in the afternoon). The similar results obtained with both specimens from the same individual indicated that all test systems were working properly for both groups of specimens. One additional control subject was not onboard the recovery ship but was available to serve as a control during the hospitalization of the crewmembers in Honolulu, Hawaii, 8 days after recovery.

After the blood was drawn, a portion was promptly added to sedimentation fluid containing dextran to sediment the erythrocytes. Leukocytes for phagocytosis and chemotaxis experiments were harvested from the leukocyte-rich plasma layer following sedimentation at room temperature for 45 to 60 minutes. A portion of the blood was anticoagulated with heparin at a concentration of 10 units/ml. This specimen was used to prepare slides for histochemical staining for acid phosphatase and alkaline phosphatase as well as for differential leukocyte counts (ref. 17-4). This blood specimen was also used in tests of leukocyte adhesion, using columns containing 50 mg of nylon fiber packed into a tuberculin syringe, with equilibration at 310 K (37° C) (ref. 17-5). Chemotaxis experiments were performed using a variation of the Boyden chamber technique developed in this laboratory (ref. 17-6). Similarly, phagocytosis studies were conducted using Lab-

tek tissue culture slides and previously described techniques (ref. 17-7). Total white blood cell counts were performed on duplicate specimens using a Coulter counter.

RESULTS

All blood samples were obtained from the Apollo commander (ACDR), command module pilot (CMP), and the docking module pilot (DMP) during the interval from 30 days before flight (F-30) to 30 days after recovery (R+30). The backup crewmembers were studied during the preflight period and served as a normal control group for this interval. Four other subjects (A, B, C, and D) were studied both in preflight testing and during the testing onboard the recovery ship. One additional subject (E) had served as an earlier control in the preflight period and was available in Honolulu to serve as a control during the hospitalization of the crewmembers beginning on day R+8.

The total white blood cell counts were reasonably stable and reproducible for each subject (table 17-I). Preflight values for the DMP were low, particularly on day F-5. Elevated leukocyte counts were noted for all three crewmembers for 2 days after recovery as well as on day R+8 (when corticosteroid administration was also a factor).

The differential leukocyte counts for the study group are presented in table 17-II. The values in tables 17-I and 17-II were used to calculate the total PMN counts presented in table 17-III. The total PMN counts were very reproducible within the same individual subjects studied serially. The low total PMN counts from the DMP on day F-5 indicates that the decrease in total leukocytes on that day was accompanied by a proportional decrease in the PMN's.

The leukocyte alkaline phosphatase is a histochemical test that generally correlates with the amount of PMN activation. The number of positive cells for this enzyme generally paralleled the total number of PMN's (table 17-IV(a)). A weighted value can be assigned to positive leukocytes by grading the reaction of individual

TABLE 17-I.—Total Leukocyte Counts

[Cells/mm³ of blood]

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	8512	5567	9605	7 192	11 427	7 200	7076
CMP	6005	6375	4913	13 448	14 395	10 000	5304
DMP	5157	4324	3631	7 036	11 582	9 800	4127
A	7495	5139	5453	6 880	7 673	--	--
B	6757	8210	7429	5 329	6 344	--	--
C	7967	6306	5209	4 502	5 390	--	--
D	--	5364	^a 6991 ^b 7397	^a 7 259 ^b 7 479	7 074	--	^a 6012 ^b 6384
E	6549	--	--	--	--	5 500	--
ACDR ^c	7736	5209	6009	--	--	--	--
CMP ^c	8679	8613	7516	--	--	--	--
DMP ^c	6043	7298	4592	--	--	--	--

^aMorning sample.^bAfternoon sample.^cBackup crewmember.

TABLE 17-II.—Differential Leukocyte Counts

[Expressed as percent]

Subject	Cell type	Day of observation						
		Before flight			After recovery			
		F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	Lymphocyte	51	40	55	23	25	27	46
	Neutrophil	46	57	42	74	73	64	46
	Eosinophil	2	1	1	1	1	6	3
	Basophil	0	1	1	0	1	0	1
	Monocyte	1	1	1	2	0	3	4
CMP	Lymphocyte	40	56	51	12	19	39	43
	Neutrophil	55	38	46	86	77	53	52
	Eosinophil	3	2	0	0	2	3	3
	Basophil	0	0	0	0	0	0	1
	Monocyte	2	4	3	2	2	5	1
DMP	Lymphocyte	56	60	68	14	17	42	42
	Neutrophil	38	36	29	79	80	52	52
	Eosinophil	3	2	1	0	0	2	3
	Basophil	1	1	0	0	0	0	0
	Monocyte	2	1	2	7	3	4	3
A	Lymphocyte	65	32	53	66	54	--	--
	Neutrophil	24	51	34	23	38	--	--
	Eosinophil	8	13	10	3	3	--	--
	Basophil	1	1	0	1	3	--	--
	Monocyte	2	3	3	7	2	--	--

TABLE 17-II.—Concluded

Subject	Cell type	Day of observation						
		Before flight			After recovery			
		F-30	F-15	F-5	R+0	R+1	R+8	R+30
B	Lymphocyte	45	38	42	45	41	--	--
	Neutrophil	49	58	51	51	52	--	--
	Eosinophil	3	2	2	0	2	--	--
	Basophil	2	0	0	0	1	--	--
	Monocyte	1	2	5	4	4	--	--
C	Lymphocyte	39	30	31	52	47	--	--
	Neutrophil	58	65	61	41	48	--	--
	Eosinophil	2	3	5	5	3	--	--
	Basophil	0	1	2	0	0	--	--
	Monocyte	1	1	1	2	2	--	--
D	Lymphocyte	--	38	50/48	41/42	38	--	47
	Neutrophil	--	59	46/49	50/54	56	--	48
	Eosinophil	--	0	0/1	4/2	2	--	2
	Basophil	--	0	0/0	0/0	1	--	0
	Monocyte	--	3	4/2	5/2	3	--	3
E	Lymphocyte	33	--	--	--	--	38	--
	Neutrophil	63	--	--	--	--	56	--
	Eosinophil	2	--	--	--	--	2	--
	Basophil	0	--	--	--	--	0	--
	Monocyte	2	--	--	--	--	4	--
ACDR ^a	Lymphocyte	46	41	54	--	--	--	--
	Neutrophil	45	53	42	--	--	--	--
	Eosinophil	2	4	1	--	--	--	--
	Basophil	2	0	1	--	--	--	--
	Monocyte	5	2	2	--	--	--	--
CMP ^a	Lymphocyte	44	36	42	--	--	--	--
	Neutrophil	51	61	55	--	--	--	--
	Eosinophil	1	0	1	--	--	--	--
	Basophil	1	1	0	--	--	--	--
	Monocyte	3	2	2	--	--	--	--
DMP ^a	Lymphocyte	49	52	50	--	--	--	--
	Neutrophil	46	43	45	--	--	--	--
	Eosinophil	1	1	0	--	--	--	--
	Basophil	2	0	0	--	--	--	--
	Monocyte	2	4	5	--	--	--	--

^aBackup crewmember.

cells from 0 to 4+. A number of cells of each degree of reactivity are multiplied by the activity score and the total value for 100 representative cells is calculated. When this was done, the crewmembers were noted to have somewhat ele-

vated values during both the preflight and postflight periods (table 17-IV(b)). This higher value was also noted in the values obtained from the CMP of the backup crew. A further weighted value can be calculated by determining the mean

TABLE 17-III.—Total PMN Counts

[Cells/mm³ of blood]

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	3916	3173	4034	5 322	8 342	4608	3255
CMP	3303	2423	2260	11 565	11 084	5300	2758
DMP	1960	1557	1053	5 558	9 266	5096	2146
A	1799	2621	1854	1 582	2 916	--	--
B	3311	4762	3789	2 718	3 299	--	--
C	4621	4099	3177	1 846	2 587	--	--
D	--	3165	^a 3215 ^b 3625	^a 3 360 ^b 4 039	3 961	--	^a 3487 ^b 3064
E	4126	--	--	--	--	3080	--
ACDR ^c	3481	2761	2524	--	--	--	--
CMP ^c	4426	5254	4134	--	--	--	--
DMP ^c	2780	3138	2066	--	--	--	--

^a Morning sample.^b Afternoon sample.^c Backup crewmember.

staining intensity of those leukocytes that are positive (table 17-IV(c)). Again, the crewmembers tended to have somewhat higher values than the normal controls, although these values are not statistically significant.

The total number of PMN's staining for the lysosomal enzyme acid phosphatase was similarly determined (table 17-V(a)). The DMP again had low values during the preflight period, with a decrease to 990 positive cells on day F-5. All crewmembers had an elevation in the number of cells staining for acid phosphatase during the immediate postflight interval. The total acid phosphatase scores (table 17-V(b)) and the mean acid phosphatase scores (table 17-V(c)) were not significantly different from the values determined in concurrent controls.

In tests of leukocyte adhesion, samples of heparinized blood were passed through nylon columns and the percentage of leukocytes adhering to the columns was calculated (table 17-VI). This test is usually reproducible if repeated for the same individual, but it is known to be influenced by high levels of steroids or by aspirin ingestion (which lower adhesion), and by inflammation

(which increases adhesion). Two of the three crewmembers (the CMP and the DMP) had decreased leukocyte adherence on day F-5. However, the concurrent controls also had generally decreased adherence values in tests performed on that day, although the extent of the decrease varied among the control individuals. The control tests were much more stable on the day of recovery (R+0) and on day R+1, possibly making the decreases in PMN adherence in members of the prime crew significant. However, because of the fluctuations observed, serial values of the prime crew are not definitely different from those obtained from the controls.

The ability of leukocytes to migrate in a modified Boyden chamber was measured both without a chemotactic stimulant (table 17-VII(a)) and in response to the chemotactic agent casein (table 17-VII(b)). A chemotactic index, expressed as the ratio of migration with casein compared to the migration with no chemotactic agent, is presented in table 17-VIII. In general, the migration of leukocytes, as quantitated by this method, remains within the normal range for this laboratory throughout the period of observation. A slightly

TABLE 17-IV.—Leukocyte Alkaline Phosphatase

(a) Total number of positive PMN's (cells/mm³ blood)

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	3564	2665	3066	4630	7841	4986	3255
CMP	2246	1696	1379	6708	8867	4876	2758
DMP	1274	1246	853	3390	8710	4790	2146
A	1673	1835	1224	886	1866	--	--
B	1788	3000	1819	1250	1188	--	--
C	3050	2090	1334	591	905	--	--
D	--	^a 3023	^a 2348	^a 1742	3129	--	^a 2301
		^b 2216	^b 2683	^b 2585			^b 1900
E	^a 2630	--	--	--	--	2587	--
	^b 3260						
ACDR ^c	1949	2098	1565	--	--	--	--
CMP ^c	4116	4729	3307	--	--	--	--
DMP ^c	2029	2479	1364	--	--	--	--

(b) Total score of positive PMN's

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	144	128	96	138	133	158	117
CMP	106	89	69	68	95	130	101
DMP	91	119	94	90	129	160	88
A	93	103	72	80	87	--	--
B	58	82	48	50	45	--	--
C	89	60	43	33	37	--	--
D	--	^a 93	^a 89	^a 63	104	--	^a 71
		^b 94	^b 88	^b 83			^b 73
E	^a 101	--	--	--	--	113	--
	^b 111						
ACDR ^c	67	104	74	--	--	--	--
CMP ^c	151	145	96	--	--	--	--
DMP ^c	95	117	82	--	--	--	--

^a Morning sample.^b Afternoon sample.^c Backup crewmember.

TABLE 17-IV.—*Concluded*

(c) Mean score of positive PMN's

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	158	152	126	159	141	166	144
CMP	156	127	113	117	119	141	120
DMP	140	149	116	148	137	170	117
A	141	147	109	143	136	--	--
B	107	130	100	109	125	--	--
C	135	118	102	103	106	--	--
D	--	^a 126 ^b 134	^a 122 ^b 119	^a 131 ^b 130	132	--	^a 108 ^b 118
E	^a 131 ^b 141	--	--	--	--	135	--
ACDR ^c	120	137	119	--	--	--	--
CMP ^c	162	161	120	--	--	--	--
DMP ^c	130	148	124	--	--	--	--

^aMorning sample.^bAfternoon sample.^cBackup crewmember.

decreased migration was noted on day R+8; but, conversely, migration of leukocytes from a normal control was increased on this day. Because this test was performed at a temporary facility in Honolulu, comparative values obtained under the same field conditions are not available to determine whether migration was actually depressed or whether this decrease was a result of the testing conditions. The chemotactic index was preserved normally in the tests performed on day R+8.

The phagocytic capacity of PMN's was measured by allowing leukocytes to form monolayers in slide culture and then adding heat-killed staphylococci for varying periods of time. The percentage of PMN's that were phagocytic was determined microscopically over intervals

from 3 to 15 minutes (table 17-IX). Although some fluctuations occurred, the PMN's from the prime crewmembers following space flight retained the ability to ingest staphylococci. When the normal number of phagocytic PMN's was calculated, increased numbers of phagocytes were found in the prime crewmembers following recovery (table 17-X). This increase in phagocytic PMN's parallels the total increase in the leukocyte count. When the number of leukocytes containing large numbers of staphylococci (five or more) was calculated, the values for the prime crewmembers were not as markedly elevated compared to those obtained from the controls (table 17-XI). The uptake of heat-killed staphylococci was not altered in any measurable degree by the space flight.

TABLE 17-V.—*Leukocyte Acid Phosphatase*(a) *Total positive PMN's (cells/mm³ of blood)*

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	3877	2697	3711	2759	6090	5196	3255
CMP	3303	2399	1966	9715	9754	5194	2758
DMP	1960	1557	990	4724	7413	5096	2146
A	1799	2569	1557	1187	2295	--	--
B	3311	4619	3334	2419	2705	--	--
C	4621	4099	2828	1329	2173	--	--
D	--	^a 4085 ^b 3165	^a 3216 ^b 3625	^a 3630 ^b 4039	3961	--	^a 3487 ^b 3063
E	^a 3415 ^b 3507	--	--	--	--	3080	--
ACDR ^c	3481	2733	2297	--	--	--	--
CMP ^c	4426	5201	3473	--	--	--	--
DMP ^c	2780	3138	1756	--	--	--	--

(b) *Total PMN score*

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	117	91	100	79	74	124	156
CMP	124	116	95	92	98	107	151
DMP	130	121	99	91	87	134	159
A	125	123	88	78	92	--	--
B	124	112	93	97	84	--	--
C	116	145	99	80	86	--	--
D	--	^a 99 ^b 96	^a 108 ^b 93	^a 89 ^b 84	87	--	^a 155 ^b 156
E	^a 126 ^b 89	--	--	--	--	125	--
ACDR ^c	124	122	100	--	--	--	--
CMP ^c	150	120	106	--	--	--	--
DMP ^c	120	129	91	--	--	--	--

^a Morning sample.^b Afternoon sample.^c Backup crewmember.

TABLE 17-V.—*Concluded*

(c) Mean PMN score

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	118	107	109	110	101	125	156
CMP	124	117	109	110	111	141	151
DMP	130	121	105	107	109	134	159
A	125	126	105	104	103	--	--
B	124	115	106	109	102	--	--
C	116	145	111	111	102	--	--
D	--	^a 116 ^b 114	^a 117 ^b 109	^a 110 ^b 105	102	--	^a 155 ^b 156
E	^a 126 ^b 105	--	--	--	--	125	--
ACDR ^c	124	123	110	--	--	--	--
CMP ^c	150	121	126	--	--	--	--
DMP ^c	120	129	107	--	--	--	--

^a Morning sample.^b Afternoon sample.^c Backup crewmember.

TABLE 17-VI.—Percentage of PMN Adherence

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	94.1	--	89.6	88.1	77.3	91.4	74.2
CMP	81.3	78.8	53.2	61.6	80.3	65.4	56.2
DMP	87.0	89.5	62.3	76.9	77.0	81.9	74.4
A	96.8	89.0	81.0	88.5	90.9	--	--
B	89.2	89.6	81.6	83.1	89.4	--	--
C	94.0	93.8	78.7	81.6	85.3	--	--
D	--	^a 84.4 ^b 84.2	^a 56.4 ^b 85.5	^a 81.4 ^b 94.3	75.6	--	^a 77.9 ^b 72.6
E	76.8	--	--	--	--	70.9	--
ACDR ^c	80.5	75.2	67.2	--	--	--	--
CMP ^c	80.5	93.1	67.4	--	--	--	--
DMP ^c	80.4	84.1	52.0	--	--	--	--

^a Morning sample.^b Afternoon sample.^c Backup crewmember.

TABLE 17-VII.—*Leukotaxis*(a) *Random PMN migration (mean number of cells per high-power microscopic field)*

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	9.6	2.3	10.7	10.0	6.9	3.9	6.3
CMP	22.3	13.4	16.0	7.4	12.9	5.6	10.3
DMP	19.5	3.6	10.9	7.7	12.8	1.7	5.6
A	5.6	7.8	9.9	4.2	3.9	--	--
B	4.7	13.9	5.3	6.1	5.6	--	--
C	6.4	5.0	29.2	5.2	3.2	--	--
D	--	^a 31.5 ^b 16.3	^a 11.1 ^b 6.5	^a 4.8 ^b 5.2	9.3	--	10.6
E	7.7	--	--	--	--	2.7	--
ACDR ^c	2.4	9.0	25.9	--	--	--	--
CMP ^c	8.0	20.9	9.2	--	--	--	--
DMP ^c	2.5	1.7	7.6	--	--	--	--

(b) *PMN chemotaxis to casein (mean number of cells per high-power microscopic field)*

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	70.9	76.4	70.8	45.2	82.9	27.2	50.3
CMP	48.4	41.2	73.5	88.7	65.2	40.9	44.7
DMP	76.0	8.3	50.2	78.7	64.5	17.6	39.2
A	22.6	41.6	63.5	73.5	81.6	--	--
B	29.9	33.2	35.9	56.4	38.8	--	--
C	37.9	21.8	45.7	12.2	60.8	--	--
D	--	^a 68.5 ^b 52.6	^a 100.4 ^b 93.2	^a 68.0 ^b 74.7	72.8	--	76.1
E	79.7	--	--	--	--	20.4	--
ACDR ^c	20.1	28.2	83.1	--	--	--	--
CMP ^c	24.0	48.0	82.8	--	--	--	--
DMP ^c	12.1	29.0	114.4	--	--	--	--

^a Morning sample.^b Afternoon sample.^c Backup crewmember.

TABLE 17-VIII.—Chemotactic Index of Leukotaxis

[Stimulated migration/random migration]

Subject	Day of observation						
	Before flight			After recovery			
	F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	7.38	33.20	6.64	4.52	11.97	7.03	7.94
CMP	2.17	3.07	4.58	12.03	5.07	7.31	4.36
DMP	3.90	2.29	4.63	10.22	5.04	10.54	7.06
A	4.04	5.33	6.40	17.37	20.76	--	--
B	6.36	2.39	6.77	9.29	6.93	--	--
C	5.92	4.36	1.57	2.34	19.00	--	--
D	--	^a 2.18 ^b 3.21	^a 9.04 ^b 14.40	^a 14.26 ^b 14.36	7.80	--	7.20
E	10.35	--	--	--	--	7.47	--
ACDR ^c	8.28	3.13	3.21	--	--	--	--
CMP ^c	3.02	2.29	9.03	--	--	--	--
DMP ^c	4.89	17.58	15.20	--	--	--	--

^aMorning sample.^bAfternoon sample.^cBackup crewmember.

DISCUSSION

The PMN is a critical cell in the defense of the host against bacterial infections. The ultimate function of this cell is the phagocytosis and killing of microorganisms that invade the tissues of the body. A sequence of earlier functions is critical, however, if the PMN is to be present in adequate numbers to influence the course of bacterial infection. Leukocytes are delivered to the tissues through the circulating blood, in which they are brought to tissues where potential infections occur. To be effective in controlling infection in tissue spaces, the leukocyte must first adhere to the surface of a blood vessel, work its way through

the walls of the small blood vessels, migrate through the tissue spaces, and collect in adequate numbers in the area of inflammation accompanying early infection. Abnormalities in PMN function that impair performance at any one of these steps can potentially cause increased susceptibility to infection.

The series of *in vitro* tests of PMN function used in this experiment was designed to systematically examine the different steps in which the PMN participates in the inflammatory response. Defective adhesion of PMN's has not been definitely documented to increase susceptibility to infection, although several clinical conditions in which infections are a problem are also

TABLE 17-IX.—Percentage of Phagocytic PMN's

Subject	Time interval, min	Day of observation						
		Before flight			After recovery			
		F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	3	9	5	5	30	1	22	10
	6	15	14	21	70	5	38	15
	10	7	24	19	72	19	38	21
	15	26	41	18	89	30	51	12
CMP	3	5	4	6	3	4	4	13
	6	11	9	7	5	4	23	17
	10	13	15	9	31	11	29	21
	15	23	28	18	37	22	15	9
DMP	3	7	6	8	6	6	3	7
	6	8	13	11	10	9	8	5
	10	6	12	8	23	17	15	25
	15	13	28	16	20	23	27	18
A	3	6	6	9	3	18	--	--
	6	13	4	15	3	31	--	--
	10	11	17	31	8	41	--	--
	15	14	29	45	28	31	--	--
B	3	14	9	20	25	13	--	--
	6	25	10	20	54	17	--	--
	10	18	16	10	89	25	--	--
	15	30	26	16	96	29	--	--
C	3	14	4	9	6	6	--	--
	6	15	8	23	12	20	--	--
	10	41	16	10	15	29	--	--
	15	20	20	14	14	57	--	--
D	3	--	a ₆ b ₁₂	a ₁₄ b ₉	a ₄ b ₇	5	--	a ₃ b ₁₀
	6	--	a ₇ b ₁₂	a ₁₄ b ₁₇	a ₉ b ₁₅	8	--	a ₈ b ₁₁
	10	--	a ₁₀ b ₂₅	a ₂₂ b ₁₂	a ₁₈ b ₁₆	7	--	a ₂₄ b ₁₃
	15	--	a ₂₂ b ₂₄	a ₁₂ b ₁₇	a ₃₅ b ₃₈	32	--	a ₁₅ b ₁₉
E	3	10	--	--	--	--	18	--
	6	16	--	--	--	--	27	--
	10	22	--	--	--	--	48	--
	15	18	--	--	--	--	42	--
ACDR ^c	3	4	3	3	--	--	--	--
	6	15	8	14	--	--	--	--
	10	20	13	18	--	--	--	--
	15	18	25	19	--	--	--	--

^a Morning sample.^b Afternoon sample.^c Backup crewmember.

TABLE 17-IX.—*Concluded*

Subject	Time interval, min	Day of observation						
		Before flight			After recovery			
		F-30	F-15	F-5	R+0	R+1	R+8	R+30
CMP ^c	3	6	2	5	--	--	--	--
	6	12	14	10	--	--	--	--
	10	22	15	11	--	--	--	--
	15	13	20	18	--	--	--	--
DMP ^c	3	5	--	8	--	--	--	--
	6	7	--	11	--	--	--	--
	10	22	--	12	--	--	--	--
	15	17	--	9	--	--	--	--

^cBackup crewmember.

accompanied by reduced *in vitro* leukocyte adhesion (corticosteroid therapy, acute alcoholism). Defective leukocyte migration and decreased phagocytosis and intracellular killing of microorganisms have been demonstrated in patients who are more susceptible to bacterial infections. This experiment did not test the capacity of PMN's from the crewmembers to kill intracellular bacteria, because of the difficulties in conducting these studies under field conditions onboard the recovery ship. The absence of any substantial change in the function studies performed suggests that a 9-day space mission does not impair PMN function to any significant extent. This finding is further substantiated by the fact that crewmembers returning from space flight have not exhibited increased clinical susceptibility to infection.

The PMN is present in the circulating blood for only a matter of hours as the cells travel from the bone marrow, where they are produced, to the tissues. As a result of this rapid turnover in leukocytes, changes in the metabolism or in the

well-being of the host may be reflected by alterations in the circulating leukocytes. Histochemical staining for granules containing acid phosphatase or alkaline phosphatase has been used to detect alterations in PMN's. In this experiment, changes in these measurements in the blood samples from the crewmembers generally paralleled the total PMN counts, as reflected in total leukocyte and differential counts.

Although blood samples were obtained from the crewmembers within 1.5 hours of reentry, the PMN population sampled at that time was probably substantially different from the PMN population that was circulating during weightlessness. Before definitive statements on the possible effects of weightlessness and space flight on PMN function can be asserted, it will be necessary to perform tests on cells actually obtained during a mission. In addition, it is conceivable that a flight of longer duration might result in substantially different effects. This area of investigation should be pursued during future space flights.

TABLE 17-X.—Number of Phagocytic PMN's

[Cells/mm³ of blood]

Subject	Time, min	Day of observation						
		Before flight			After recovery			
		F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	3	352	159	202	1597	83	1155	326
	6	587	444	847	3725	417	1994	488
	10	274	762	767	3832	1585	1994	684
	15	1018	1303	726	4737	2502	2676	391
CMP	3	165	97	154	359	443	212	359
	6	363	218	179	599	443	1219	469
	10	429	264	230	3710	1219	1537	579
	15	760	678	461	4429	2438	795	248
DMP	3	137	100	84	342	556	153	150
	6	157	217	116	569	834	408	107
	10	118	201	84	1310	1575	764	537
	15	255	468	169	1140	2131	1376	386
A	3	108	157	167	47	525	--	--
	6	234	105	278	47	904	--	--
	10	199	446	575	127	1196	--	--
	15	252	760	834	443	904	--	--
B	3	464	429	758	679	429	--	--
	6	794	476	758	1468	561	--	--
	10	596	762	379	2419	825	--	--
	15	993	1238	606	2609	957	--	--
C	3	647	164	286	111	155	--	--
	6	693	328	731	222	518	--	--
	10	1895	656	317	277	751	--	--
	15	924	820	445	258	1476	--	--
D	3	--	a ₂₄₅	a ₄₈₉	164	198	--	a ₁₀₅
		--	b ₃₇₉	b ₃₂₆			--	b ₃₀₆
	6	--	a ₂₈₆	a ₄₈₉	370	317	--	a ₂₇₉
		--	b ₃₇₉	b ₆₁₆			--	b ₃₃₇
	10	--	a ₄₀₉	a ₇₆₉	740	277	--	a ₈₃₇
		--	b ₇₉₁	b ₄₃₅			--	b ₃₉₈
	15	--	a ₈₉₉	a ₃₈₆	1439	1286	--	a ₅₂₃
		--	b ₇₆₀	b ₆₁₆			--	b ₅₈₂
E	3	206	--	--	--	--	554	--
	6	330	--	--	--	--	832	--
	10	412	--	--	--	--	1478	--
	15	742	--	--	--	--	1294	--

^aMorning sample.^bAfternoon sample.

TABLE 17-X.—*Concluded*

Subject	Time, min	Day of observation						
		Before flight			After recovery			
		F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR ^c	3	139	83	76	--	--	--	--
	6	522	221	353	--	--	--	--
	10	696	359	454	--	--	--	--
	15	626	690	479	--	--	--	--
CMP ^c	3	266	105	207	--	--	--	--
	6	531	736	413	--	--	--	--
	10	974	788	455	--	--	--	--
	15	575	1051	744	--	--	--	--
DMP ^c	3	139	--	165	--	--	--	--
	6	195	--	227	--	--	--	--
	10	612	--	248	--	--	--	--
	15	473	--	186	--	--	--	--

^cBackup crewmember.TABLE 17-XI.—*Number of Phagocytic PMN's With Five or More Staphylococci*

Subject	Time, min	Day of observation						
		Before flight			After recovery			
		F-30	F-15	F-5	R+0	R+1	R+8	R+30
ACDR	3	0	0	0	426	0	367	33
	6	0	64	0	852	334	840	0
	10	0	159	81	1277	834	525	98
	15	157	571	121	2076	1501	1102	163
CMP	3	0	0	0	120	0	0	28
	6	33	24	0	120	111	106	0
	10	33	97	51	2513	443	265	110
	15	33	145	26	3351	1108	424	28
DMP	3	0	0	0	57	278	0	0
	6	0	17	0	0	278	0	0
	10	20	0	11	456	648	204	64
	15	0	117	0	513	1019	204	129

TABLE 17-XI.—Concluded

Subject	Time, min	Day of observation						
		Before flight			After recovery			
		F-30	F-15	F-5	R+0	R+1	R+8	R+30
A	3	0	0	0	0	58	--	--
	6	18	0	37	0	117	--	--
	10	18	26	297	63	233	--	--
	15	0	184	222	233	204	--	--
B	3	33	48	0	163	132	--	--
	6	0	0	0	462	330	--	--
	10	0	286	0	1142	495	--	--
	15	331	667	75	1359	627	--	--
C	3	92	0	0	0	0	--	--
	6	0	0	0	55	129	--	--
	10	508	82	0	148	285	--	--
	15	231	328	32	148	751	--	--
D	3	--	a ₀ b ₀	a ₇₀ b ₀	41	0	--	a ₀ b ₀
	6	--	a ₀ b ₀	a ₇₀ b ₀	0	40	--	a ₃₅ b ₆₁
	10	--	a ₈₂ b ₃₂	a ₀ b ₀	205	119	--	a ₁₀₅ b ₉₂
	15	--	a ₂₈₆ b ₃₇₉	a ₀ b ₀	1234	634	--	a ₁₀₅ b ₃₀
E	3	0	--	--	--	--	92	--
	6	0	--	--	--	--	185	--
	10	0	--	--	--	--	400	--
	15	7	--	--	--	--	462	--
ACDR ^c	3	0	0	0	--	--	--	--
	6	104	0	25	--	--	--	--
	10	104	0	25	--	--	--	--
	15	104	110	101	--	--	--	--
CMP ^c	3	44	0	0	--	--	--	--
	6	133	53	0	--	--	--	--
	10	133	158	83	--	--	--	--
	15	89	158	83	--	--	--	--
DMP ^c	3	28	--	0	--	--	--	--
	6	28	--	0	--	--	--	--
	10	167	--	0	--	--	--	--
	15	83	--	0	--	--	--	--

^a Morning sample.^b Afternoon sample.^c Backup crewmember.

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